

Piston ring as well as the method for the production thereof

### Specification

The invention concerns a piston ring, containing a contact surface supplied with a contact surface profile as well as an upper and a lower side surface.

In patent EP-B 0 702 097, a sliding member is to be seen in which the surface of a substrate is coated with a compound, which at a minimum contains chromium nitride, in which a column-like crystal structure in a tension fissure surface of the coating is present, wherein the columns are aligned from the substrate surface towards the coating surface. The porosity of the coating should, on the basis of the chromium nitride, lie between 1.5 and 20%, wherein the thickness of the coating is between 1  $\mu\text{m}$  and 80  $\mu\text{m}$ . If required, an intermediate layer, composed of chrome, can be provided in between the base material and the coating. The sliding member can be a piston ring, in which the coating is provided, at least on the peripheral slide surface. The sliding member should be coated either with metal nitride or with metal carbide, where the application can occur either through a PVD (physical vapor deposition) process or a CVD (chemical vapor deposition) process. The composition of the coating consists here of CrN, Cr<sub>2</sub>N or a mixture thereof, in a uniform phase. Contact surface coatings, which have been deposited with a PVD or CVD process on the contact surface of the sliding member (piston rings), have very positive effects on their technical operation. A disadvantage is that the PVD coatings do not economically allow grinding processing. Therefore, till now only a piston ring construction that after the coating required no grinding processing could be used.

One of such a design is in all known cases a completely coated contact surface. Because the compound between PVD coating and the base material is under very high stresses, in order to avoid edge breakage, a strongly

beveled edge must be used. However, this significantly reduces the capacity of the rings to wipe off oil.

However, it would be desirable to have a ring with a PVD coated contact surface and a sharp lower contact surface edge.

Piston rings with sharply-edged contact surface edges are known for an optimal oil wiping behavior. However, such rings are not realizable with the named state of the art, so that despite the high-grade contact surface coating, the practical scope of application, rather, exists only conditionally.

The object of the invention is to build on the known state of the art according to EP-B 0 702 097, so that on one hand the complete contact surface does not have to be provided with such a coating, and, on the other hand, an optimal oil wipe-off in operating conditions is guaranteed.

This task is solved by a piston ring containing a contact surface supplied with a contact surface profile as well as an upper and a lower side surface, in which at the minimum, the contact surface is supplied with a vapor deposition coating, in such a way that a portion of the contact surface is supplied with a removable cover, so that after fabrication of the vapor deposition coating and removal of the cover, an essentially sharp-edged contact surface edge exists between the contact surface and at least one of the side surfaces.

Advantageous further developments of the object of the invention are to be seen in the associated representational dependent claims.

The task is also solved by means of a method for the fabrication of a vapor deposition coating on a contact surface of a piston ring supplied with a contact surface profile, in which a base member is provided with a contact surface profile, wherein the base member is supplied with a cover outside of the contact surface profile, the vapor deposition coating is applied on the contact surface and subsequently the cover is removed, so that following the removal of the

cover there exists between the contact surface and at least one of the side surfaces of the base member, an essentially sharp-edged contact surface edge.

Advantageous further developments of the method of the invention are to be seen in the associated method according to the dependent claims.

Thus, the proven PVD or CVD process can be further meaningfully used through the object of this invention, and furthermore, the effect of the oil wipe off can also be advantageously improved.

The object of the invention builds upon the base members used in practice, that already are supplied with varying formed contact surface profiles, for example, single or multi-sided chambering, partially conical contact surface areas, grooves or similar. A further advantage of the object of the invention is based in, that depending on the application, the base member can be partially supplied with a galvanized coating that is composed of, for example, chrome. The base member itself can be composed of steel or cast iron.

In analogy to the state of the art according to EP-B 0 702 097, the vapor deposition coating can be produced based on Cr and N, and in a similar means, applied of the contact surface of the base member.

Depending on the case of use, it can be sensible to form the contact surface profile with at least one undercut, so that in the state of operation of the piston ring an oil retaining reservoir is formed between the remaining cross member, or the chamber wall, and the vapor deposition coating.

Likewise it is conceivable, to form the contact surface profile in such a way that a porous transitional area is provided between the remaining cross member, or the chamber wall, and the vapor deposition coating. Conditionally due to the

porosity, an area for oil retention could likewise be created.

The removable cover could be of the most varied type, where the person skilled in the art would choose the appropriate cover for the intended case of use, also with regards to economic considerations. The cover can, for example, be a single piece formed out of the material of the base member, and after the application of the vapor deposition coating, it is removed from the base member. A particular advantage is associated with this, in that the otherwise the very hard vapor deposition coating that is not economically grindable, can, through a simple means, be separated, so that, on the one hand, a wear resistant protection layer is created, and, on the other hand, an essentially sharp-edged contact surface edge is created. Likewise, metal or plastic bands are conceivable as covers.

The object of the invention is illustrated on the basis of the embodiment examples in the drawing and is described in the following. They show:

Figure 1      Conceptual representation of a piston ring coating method with a partial cover of the individual piston rings.

Figures 2 through 5      Example of piston rings with varied profiles, on one side with the cover, and on the other side with the cover removed.

Figure 1 shows as the conceptual sketch of several piston rings 1, arranged one after the other, that are supplied with a vapor deposition layer. Each piston ring 1 possesses a contact surface 3 supplied with a contact surface profile 4, here built by a single sided chamber. The remaining cross member 5 is supplied with a removable cover 6. After the cover 6 has been applied, the piston ring packet, formed from the piston rings 1 – for example, as set out in EP-B 0 702 097 – is subjected to a vapor deposition coating, according to the PVD process, created in such a way that a vapor deposition coating 2, in this example consisting of CrN, is created.

Following the coating, the piston rings 1 are separated and the cover 6 removed. If a projection in the area of the cross member 5 remains, this can be processed in a simple form, to achieve – so far as this is desired – a smooth surface with the vapor deposition layer 2. The vapor deposition layer should amount to, in this example, 30  $\mu\text{m}$ .

The Figures 2 through 5 show piston rings with varied contact surface profiles 4, in various machined states.

The Figures 2a and 2b show a slant 7 that runs under a tilt angle into the contact surface profile 4. The cover 6 is applied on the remaining cross member 5. Figure 2b shows end state of the piston ring 1, after the cover 6 was removed. It can be recognized that between the contact surface 3, and in this example, the lower side surface 8, an essentially sharp-edged contact surface edge 9 is formed.

The Figures 3a and 3b are to be evaluated in a similar way, in which here a rounded area 10 is given, that runs into the contact surface profile 4 from the cross member 5. The cover 6 is to be, in this example, formed out a single piece of the base material of the piston rings 1. After application of the vapor deposition coating 2, the provided material can, in the area of the cover 6, be ground. If this is not reasonable due to economic considerations, it is possible that the cross member 5 is removed, for example, by turning or milling, until, for example, a level surface is created with the vapor deposition coating 2. The person skilled in the art would choose the particular machining process dependent on the application case. Here also – as shown in Figure 3b – a sharp contact surface edge 9 is formed after the removal of the cover 6.

The Figures 4a and 4b show a further variation. The piston ring 1, after the application of the vapor deposition coating 6[sic. Should be 2] is partially supplied with a galvanized layer 12, for example, out of chrome. In contrast to Figures 2 and 3, the profile 4 is provided in such a way, that undercut areas 11 are formed,

into which the vapor deposition material can permeate only partially or not at all. After removal of the cover 6 – depending on the angle of inclination – either porous areas are formed here or even chambers, which in the operating state of piston rings 1 serve as oil holding reservoirs.

The Figures 5a and 5b show another variation of a contact surface profile 4. A groove with supplied slants is illustrated, in which each outer cross member 5 is supplied with a cover 6. After removal of the cover 6 – as shown in Figure 5b – a sharp-edged contact surface edge 9 is formed between the contact surface 3 and the side surface 8.